characteristic or property of the fluid or of a component of the fluid, such as particles, dissolved salts or other solutes or other species in the fluid. Especially preferred embodiments of the fluid handling devices disclosed here are operative to perform liquid separation analyses. That is, the devices perform or are adapted to function in a larger system which performs, any of various different fluid separation test or analysis methods, typically along with ancillary and supporting operations.

[0008] In accordance with another aspect, the fluid handling devices include a substrate assembly comprising a multi-layer laminated substrate microfabricated to define at least one microscale fluid flow passage. Numerous materials are suitable for the individual layers of the substrate, depending on the use environment and functionality intended for the device. Suitable materials include, for example, polymers, plastics, e.g. rigid or flexible plastics, glass, ceramic, metal, silicon, etc. and combinations of numerous materials. In certain embodiments, additives, such as carbon black, dyes, titanium dioxide, gold, e.g. electroplated gold or electrolessly plated gold, carbon particles, additional polymers, e.g. a secondary polymer or second phase polymer reactive with the primary polymer of the laminate layer, IR absorbing materials, and the like, may be included, as a surface coating and/or a body filler, in the materials used to form any of the layers of the multi-layer laminated substrate. A layer formed of materials suitable for micromachining may be used, for example, with another layer formed of material compatible with waveguide, thick film, thin film or other surface treatments. Given the benefit of this disclosure, it will be within the ability of those skilled in the art to select materials for the substrate suited to the particular application. The substrate assembly may take any of numerous forms, e.g., a manifold in fluid communication with an instrument, a cartridge, such as the cartridge described in the commonly assigned U.S. Patent Applications incorporated by reference, or a component of a cartridge for performing one or more operations on a fluid, for example, fluid analysis, testing, reactions, detection or the like, such as by gas chromatography, liquid chromatography, electrophoresis, or other fluid separation and analytical techniques. As further discussed below, any one or more of various different operations may be performed by the substrate assembly, employing, for example, heating, cooling, mixing, electrical or electromagnetic or acoustical (e.g., ultrasonic) forces, pressure differentials, etc. Exemplary unit operations which may be performed by various different embodiments of the substrate assembly disclosed here include fluid mixing, reacting, analyzing, extraction, amplification or focusing or concentration, labeling, filtering, selection, purification, etc. Information such as the identity of the substrate assembly, the results of any such operation(s) and/or when they occurred or the conditions at that time may optionally be digitally or otherwise recorded, such as in an on-board memory unit or the like carried by the substrate assembly or by another component of a system in which the substrate assembly is employed or in communication with, either by wire or by wireless communication, for example. One or more of the aforesaid operations may be integrated into the substrate assemblies disclosed herein.

[0009] In accordance with another aspect, the substrate assemblies disclosed here are "microfluidic" in that they operate effectively on micro-scale fluid samples, typically having fluid flow rates as low as about 1 ml/min, preferably about 100 ul/min or less, more preferably about 10 ul/min or less, most preferably about 1 ul/min or less, for example about 100 nanoliters/min. Total fluid volume for an LC or other such fluid separation method performed by substrate assemblies disclosed here, e.g., in support of a water quality test to determine the concentration of analytes in the water being tested, in accordance with certain preferred embodiments, can be as small as about 10 ml or less, or 1 ml or less, preferably 100 microliters, more preferably 10 microliters or even 1 microliter or less, for example, about 100 nanoliters. As used herein, the term "microscale" also refers to flow passages or channels and other structural elements of the multi-layer laminated substrate. For example, the one or more microchannels of the substrate preferably have a cross-sectional dimension (diameter, width or height) between about 500 microns and about 100 nanometers. Thus, at the small end of that range, the microchannel has cross-sectional area of about 0.01 square microns. Such microchannels within the laminated substrate, and chambers and other structures within the laminated substrate, when viewed in cross-section, may be triangular, ellipsoidal, square, rectangular, circular or any other shape, with at least one and preferably all of the cross-sectional dimensions transverse to the path of the fluid flow. It should be recognized, that one or more layers of the laminated substrate may in certain embodiments have operative features, such as fluid channels, reaction chambers or zones, accumulation sites etc. that are larger than microscale. Additionally, the multi-layer laminated substrate may be attached to one or more devices that are larger than microscale and optionally have an adaptor such as a valve, for example, to provide a suitable interface with the laminated substrate and/or to regulate the fluid flow rate into the laminated substrate. The multi-layer laminated substrates disclosed here can provide effective fluid analysis systems with good speed of analysis, decreased sample and solvent consumption, the possibility of increased detection efficiency, and in certain embodiments disposable fluid-handling devices.

[0010] In accordance with an additional aspect, the microfluidic nature of the substrate assemblies disclosed here provides significant commercial advantage. Less sample fluid is required, which in certain applications can present significant cost reductions, both in reducing product usage (for example, if the test sample is taken from a product stream) and in reducing the waste stream disposal volume. Samples can be concentrated prior to separation and/or entry into the microfluidic substrate assemblies. In addition, the microfluidic substrate assemblies can, in accordance with preferred embodiments, be produced employing micro electromechanical systems (MEMS) and other known techniques suitable for cost effective manufacture of miniature high precision devices. The micro-scale fluid flow channel(s) of the multi-layer laminated substrate of the microfluidic substrate assembly and other operational features and components of the microfluidic substrate assembly, such as components for liquid chromatography or other fluid separation methods, heating or cooling fluid handled by the assembly, generating electrical or electromagnetic or acoustical (e.g., ultrasonic) forces on the fluid, generating high pressures or pressure differentials, fluid mixing, reacting, analyzing, extraction, amplification or focusing or concentration, labeling, filtering, selection, purification, etc., can be integrated into the multi-layer laminated substrate, mounted onto the substrate as an on-board component or incorporated